

CHAPTER 5

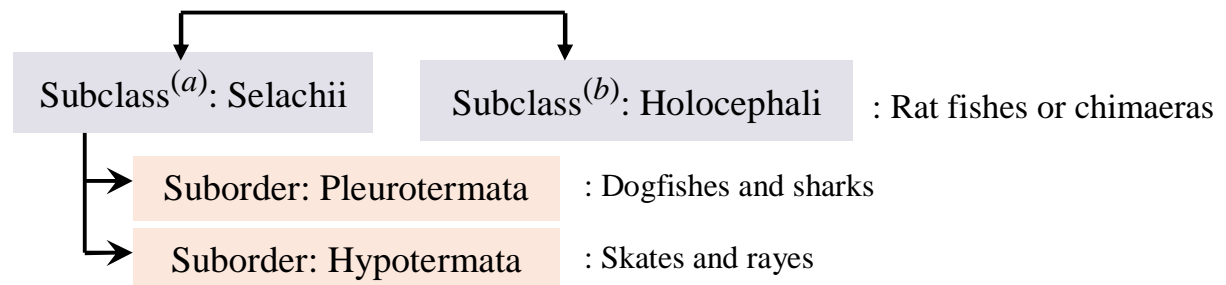
CARTILAGENOUS FISHES

SCYLIORHINUS CANICULA

(DOG FISH)

INTRODUCTION

The Chondrichthyes is a class of vertebrates containing cartilaginous fishes. In these animals true bone is absent although the deposition of calcium take place in the cartilage. The class is subdivided to main subclasses:



MAIN CHARACTERISTICS OF CARTILAGENOUS FISHES

- 1) With true jaws and all members are marine predators with cartilaginous endoskeleton.
- 2) Mouth opening lies ventrally and crescent in shape.
- 3) With denticles or placoid scales.
- 4) With true teeth which are composed of calcium and which are grown in rows throughout the life of the shark and which are periodically shed.
- 5) With paired fins-pectoral fins and anal or pelvic fins.
- 6) Caudal fin heterocercal.
- 7) Absence of swim bladder.
- 8) Sensory pits along the side forming the lateral line.
- 9) With 5 pair of unprotected gill slits.
- 10) Notocord replaced in the embryo by vertebrae composed of cartilage.

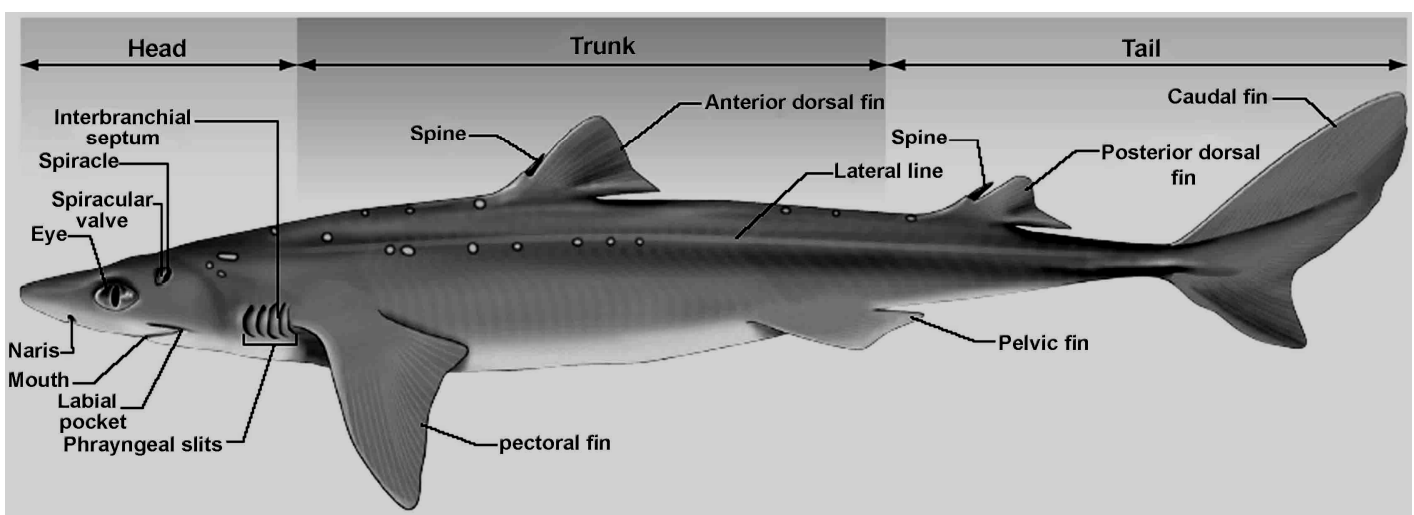
11) Dioecious and sexually dimorphic, Oviparous or oviparous.

12) With internal fertilization involving copulation

EXTERNAL FEATURES

The body is elongated and fusiform, which facilitates movement through the water. The **head** extends posteriorly to the end of the pharyngeal slits and includes the laterally placed eyes. The nares lie ventrolaterally on the tapered snout. The ventrally located mouth is supported by upper and lower jaws that have rows of sharp teeth. The spiracle is a relatively large opening into the pharynx and lies directly posterior to each eye. Its anterior wall contains a fold of tissue, the spiracular valve, that can be folded over the opening to close the spiracle. The valve bears a pseudobranch, a reduced gill, on its posterior surface. A row of five pharyngeal slits, separated by four interbranchial septa, lie posterolaterally on either side and lead into the pharynx.

The **trunk** follows the head and extends posteriorly to the midventrally located cloaca. The median anterior dorsal fin lies middorsally on the trunk and carries a sharp spine anteriorly. The paired large pectoral fins lie anteriorly, just behind the gill slits, while the paired pelvic fins lie at the end of the trunk, one on either side of the cloaca. In the male an elongated, cylindrical, and dorsally grooved clasper, a copulatory organ, lies between the cloaca and pelvic fin.



Antero-posteriorly, extending the lateral line canal, a cutaneous tube that contains sensory nerve endings and opens to the surface by way of tiny pores. The lateral line canal is the predominant part of the lateral line system, a system of sensory cells responsive to pressure changes caused by vibrations and movements in the water.

In the male, the genital ducts and urinary ducts open at the tip of the urogenital papilla, a large cone-like structure lying in the cloaca. In females, only the urinary ducts open at its tip, it is termed the urinary papilla. The anus, the posterior opening of the digestive tract, opens into the cloaca anterior to the papilla. The abdominal pores, one each on the posterolateral side of the cloaca are extend into the pleuroperitoneal cavity and may allow removal of excess fluid from the cavity

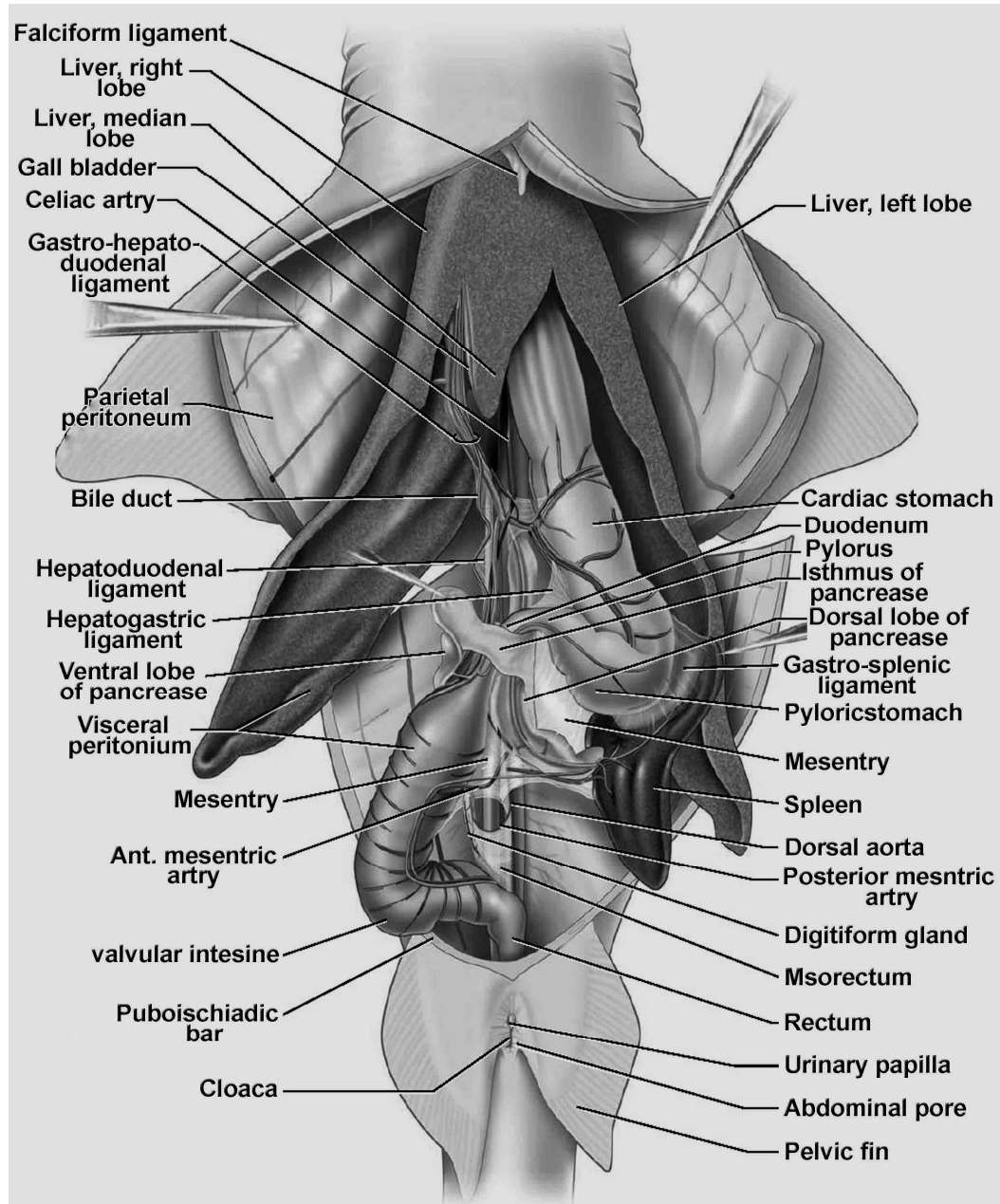
The **tail** extends posteriorly from the cloaca and carries the well-developed caudal fin. Lateral undulations of the tail and caudal fin produce the propulsive force that moves the shark forward. The posterior dorsal fin, another medial fin, lies at the anterior part of the tail and also has an anterior spine.

DIGESTIVE SYSTEM

The ventral and crescentic **mouth** opens into dorsoventrally compressed spacious buccal cavity which is lined with thick mucous membrane. The mucous membrane is raised ventrally into a thick fold forming the non-muscular and non-glandular **tongue**. The teeth are oblique and have sharp cusp, the **teeth** are all alike in shape, homodont, and are borne in several parallel row on the inner margin of upper and lower jaws. The buccal cavity opens into pharynx, on either side of which lie the internal opening of spiracle and gill slits.

The **liver** occupies most of the anterior part of the peritoneal cavity and the right and left lobes extend posteriorly on either side. A small,

median lobe extends for a short distance between them and contains an elongated **gall bladder**. The main part of the **stomach** is the body. The smaller, narrower, posterior part is the pyloric region. It constricts at the



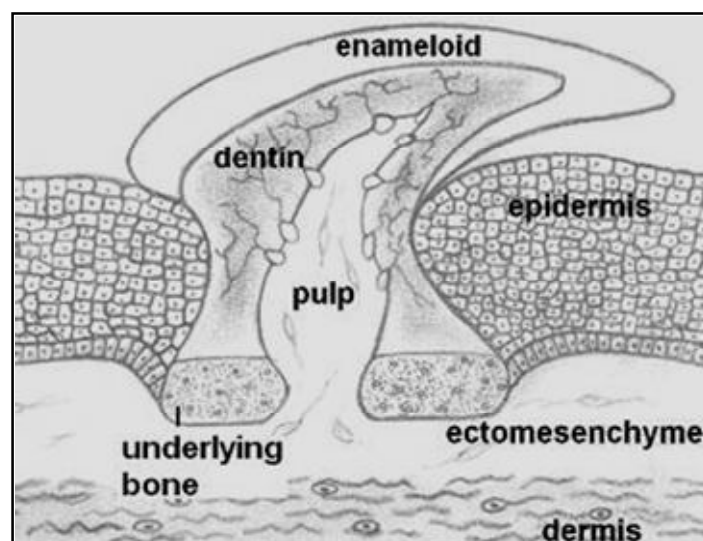
pylorus, which marks the separation between the stomach and intestine. The triangular **spleen** is the large, dark-colored organ at the posterior end of the stomach. The **pancreas** consists of two parts linked by a narrow isthmus. A flattened, oval ventral lobe lies on the antero-ventral surface of the **intestine**. The narrow, elongated dorsal lobe extends posteriorly.

The intestine of the shark is subdivided into a short **duodenum**, a valvular intestine, and a narrow colon. The valvular intestine bears a **spiral valve**, an internal subdivision that increases the effective length of the intestine. The colon, lacking a spiral valve, extends from the valvular intestine. It is joined by the salt-excreting **digitiform gland**, before continuing into the **cloaca** as the **rectum**.

SKELETAL SYSTEM

EXOSKELETON

The skin is covered with minute dermal denticles or **placoid scales** which are arranged in regular oblique row and form the exoskeleton of the dog fish. These scales are derived from the skin. Each scale consists of a diamond shaped calcified **basal plate** from which a flat trident spine which directed backward. The basal plate is formed of calcified tissue closely allied to the cement of our teeth. A small opening in the centre of the plate leads into a cavity, the **pulp cavity**, which containing numerous dentine forming odontoblast cells. The spine is made up of **dentine**, a calcareous substance externally covered by another hard dense **enamel** like material. The dentine is relatively spongy through which ramify numerous fine branches or canaliculi.



placoid scales.

ENDOSKELETON

The skeleton of dog fish may be divided into the **axial skeleton** and **appendicular skeleton**. The axial skeleton consists, in all craniates, of skull and vertebral column. The appendicular skeleton consists of girdles and fins, both pectoral and pelvic.

AXIAL SKELETON

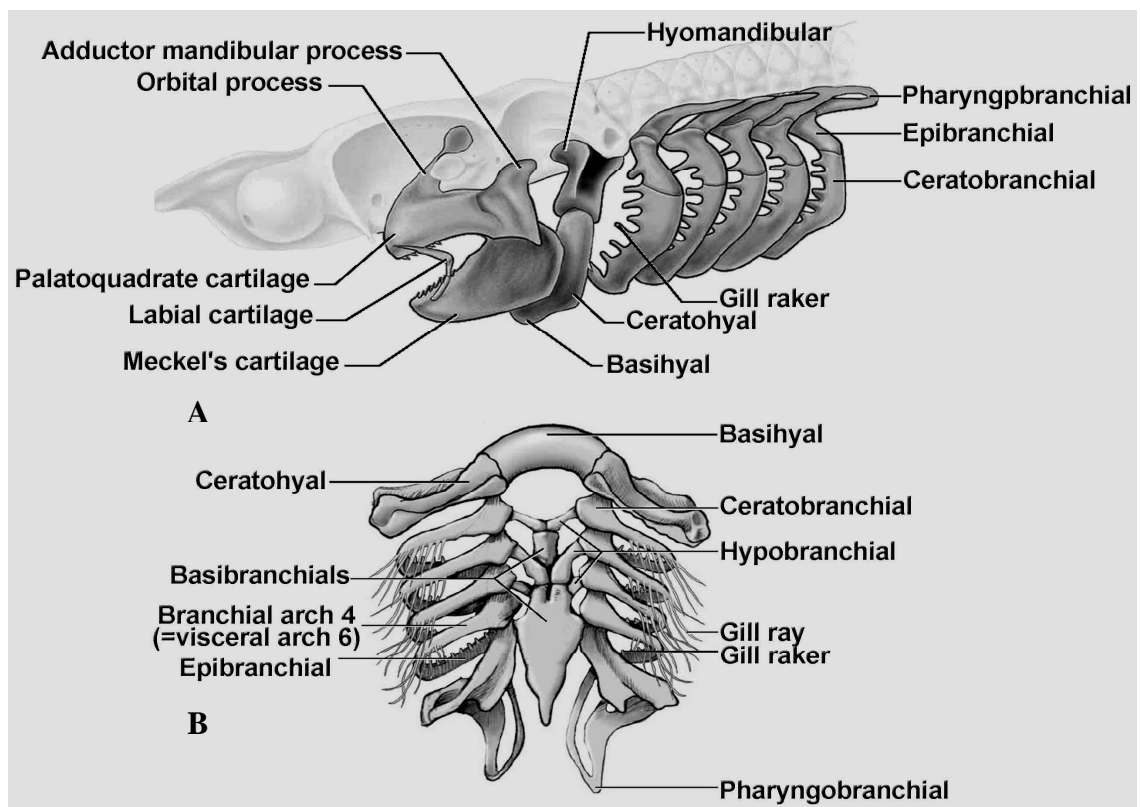
SPLANCHNOCRANIUM

The splanchnocranium includes the seven visceral arches: the mandibular arch, hyoid arch, and five branchial arches. The mandibular and hyoid arches are highly modified for their use as jaw elements. The branchial arches support the interbranchial septa and lie between successive gill slits.

The **mandibular** arch is the largest and built up jaws. It is mainly formed of paired palatoquadrate cartilages fused anteriorly to form upper jaw. The ventral half of mandibular arch forms the lower jaw which consists of paired Meckel's and labial cartilages.

The **hyoid** arch is modified to support the jaws. The dorsal segment of the hyoid arch, on each side, is the hyomandibular. Laterally, ceratohyal articulate ^A with hyomandibular dorsally and with median ^B ventral basihyal

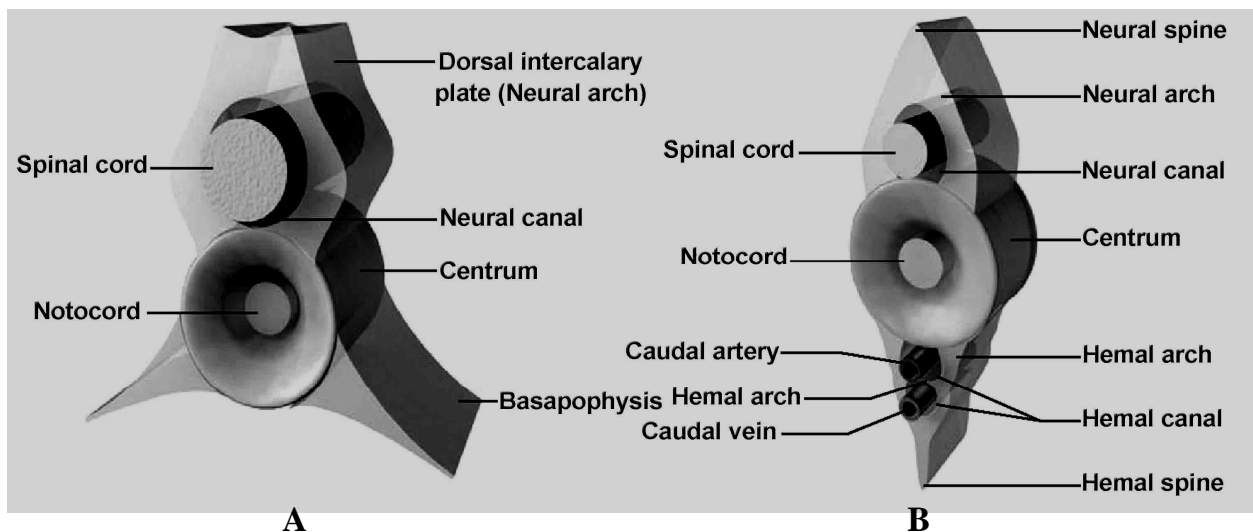
The remaining arches are **branchial arches**. Each arch is formed, in dorsal to ventral order, from paired pharyngobranchials, epibranchials, and ceratobranchials. Ventrally the arches are completed by three paired hypobranchials and two median, unpaired basibranchials. The pharyngobranchials of visceral arches 6 and 7 are fused.



VERTEBRAL COLUMN

The entire length of the vertebral column consists of two main types of vertebrae, the trunk and caudal vertebrae. Each **trunk** vertebra of the vertebral column is made up of vertebral body or centrum. The tips of the neural plates bear a neural spine and between the successive plates intercalary plates which form the neural arches. Between the neural arches there is neural canal for the passage of spinal cord. Each plate is pierced by a foramen for the root of a spinal nerve. A basapophysis projects, on either side, from the ventrolateral surfaces of the centra of the trunk vertebrae. A slender rib attaches to the basapophysis.

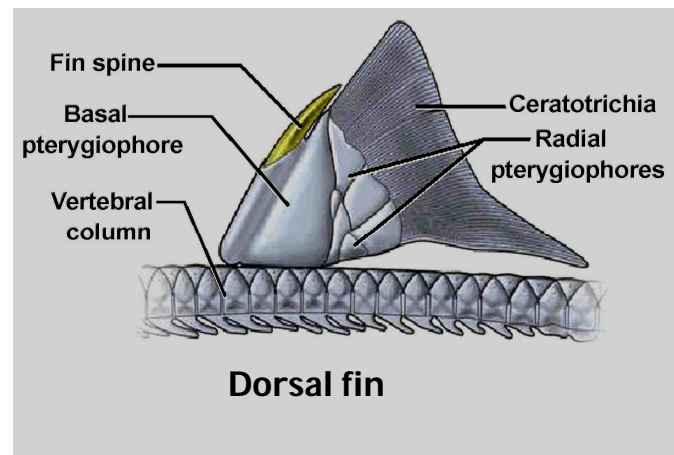
Caudal vertebrae have the same structure of the trunk ones, but the centrum bears ventrally a plate of cartilage that forms the hemal arch for the caudal artery and vein. A hemal spine extends ventrally from the hemal arch.



Vertebrae of dogfish
(A) Trunk vertebra, (B) Caudal vertebra.

APPENDICULAR SKELETON

The anterior and posterior dorsal fin are reinforced by the vertebral column, each of them has a large proximal basal pterygiophore, to which the fin spine is anchored anteriorly. At the distal region there are a series of radial pterygiophores and, finally, the ceratotrichia, which are fibrous dermal rays. The caudal fin is of heterocercal type—asymmetric, with the vertebral axis curving into the dorsal half of the fin

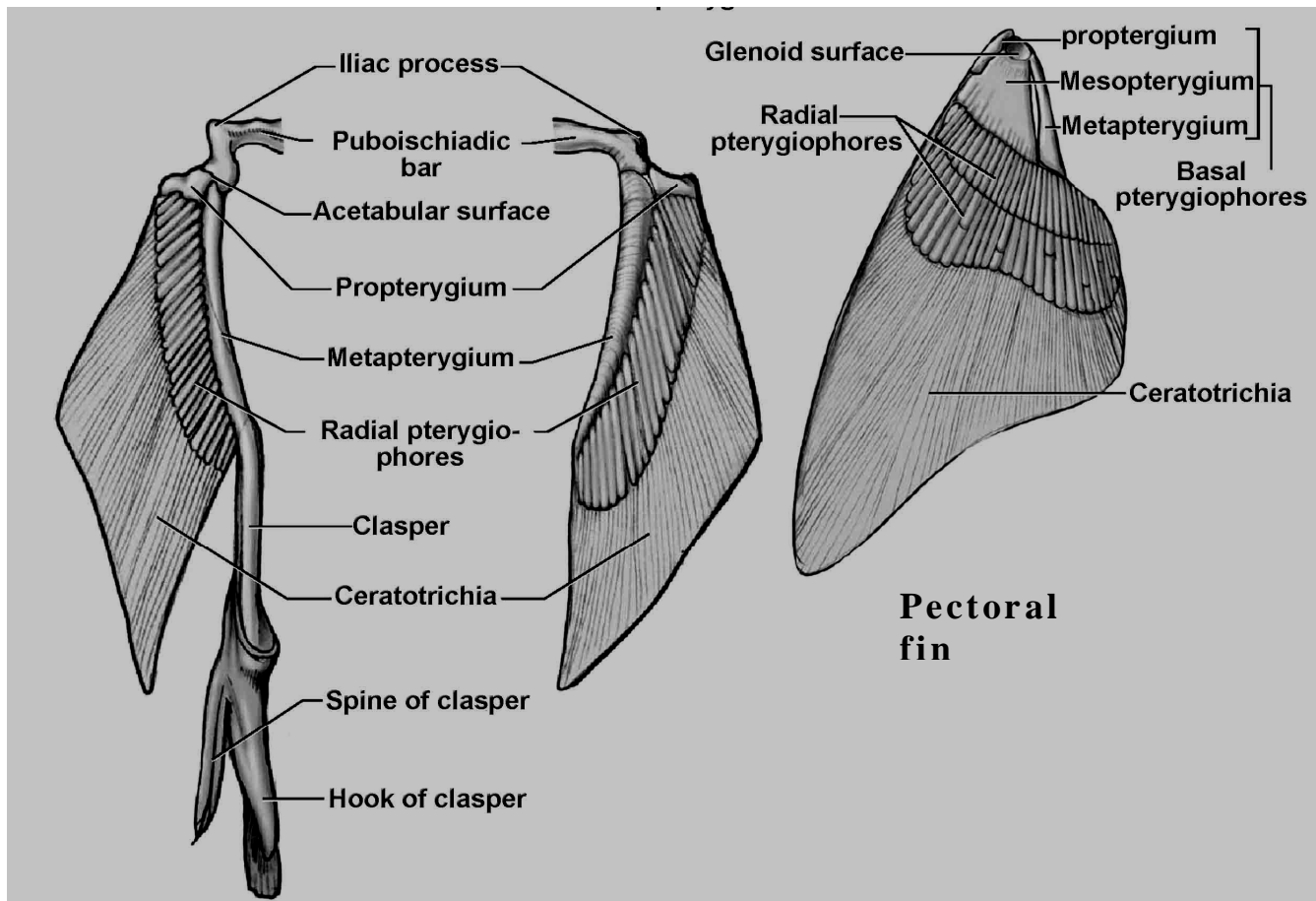


PECTORAL AND PELVIC GIRDLE

The **pectoral** girdle has coracoid bar a connection area between the two halves. This area articulates with the glenoid surface. The pectoral fin has proximal basal and radial pterygiophores, followed by ceratotrichia. Three basals are recognized: the propterygium, mesopterygium, and metapterygium, in anterior to posterior order. The radials of the pectoral fin are rod-like structures

The **pelvic** girdle consists of a single element, the puboischiadic bar which articulate with the acetabular surfaces. An iliac process lies near each acetabular surface. The pelvic fin of the female and male are similar in bearing a short propterygium and a stout, elongated metapterygium that extends posteriorly. The pelvic fin of the male differs in bearing a clasper, formed from modified radials, that functions in the

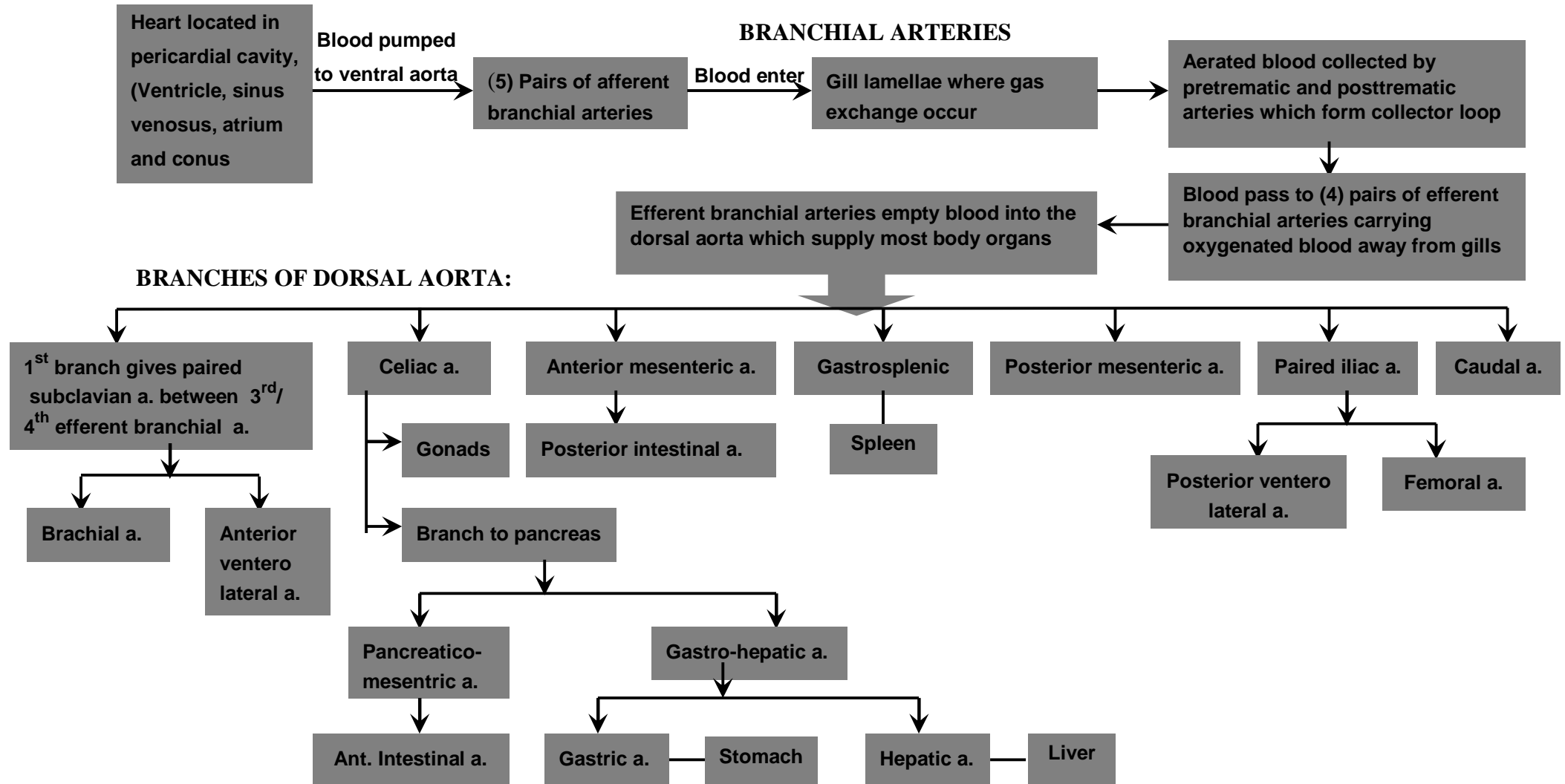
intromission of sperm into the cloaca of the female. The clasper extends posteriorly from the metapterygium and bears a hook and spine distally.



Pelvic fin

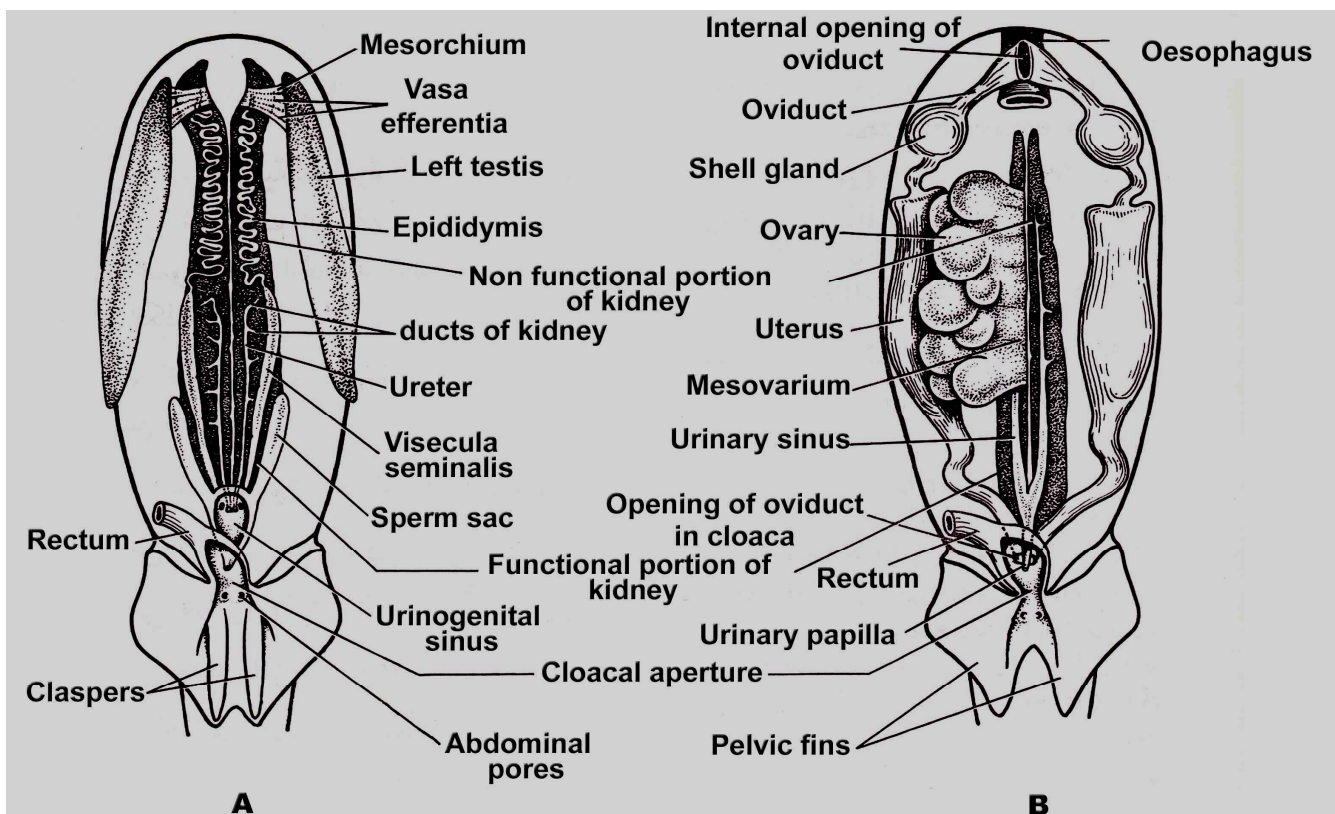
CIRCULATORY SYSTEM

ARTERIAL CIRCULATION



FEALE URINOGENITAL SYSTEM

One pair of ovaries suspended from the roof of anterior pleuroperitoneal cavity by meserchium. An oviduct lies on the ventral surface of each kidney. Eggs are shed into pleuroperitoneal cavity and pass through the oviduct where the nidamental (shell) gland secretes membranes around eggs; it is also the location where fertilization occurs. The fertilization is internal and copulation occurs, male insert the claspers in female's cloaca where male coils itself around the body of female in a curious back-to-back position. The uterus is greatly enlarged and developing embryos nourished mainly with yolk which enters the embryo via a stalk.



Urinogenital system of dogfish (A) Male, (B) Female

CHAPTER 6

BONY FISHES

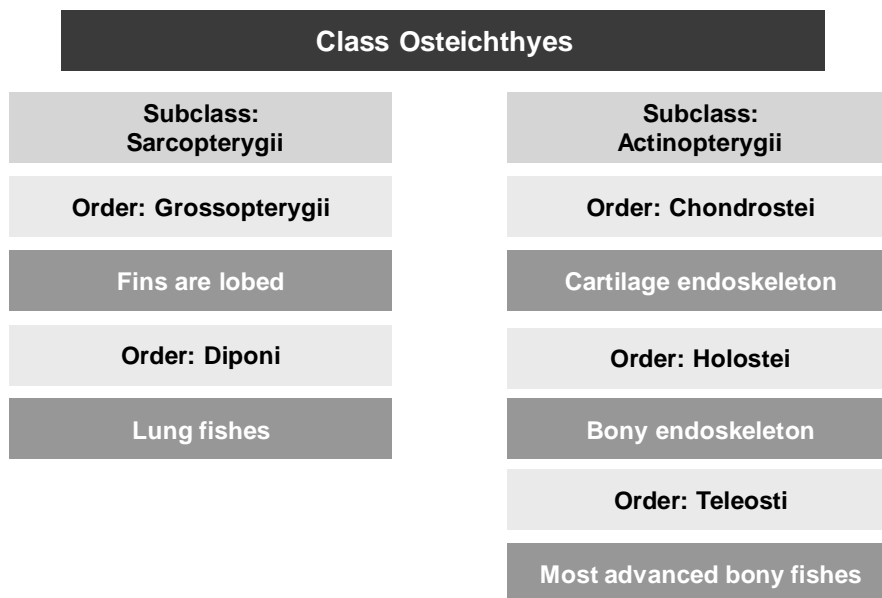
Tilapia nilotica

(Bolti)

INTRODUCTION

The class Osteichthyes includes a large assemblage of true bony fishes. There are well over 30,000-40,000 living species, both freshwater and marine. Some of the freshwater forms are the carp, perch, bass, trout, catfish, sucker, etc. Representatives of marine fishes are the tarpon, meckerel, tuna, sailfish, barracula, flying fish, etc.

Classification



MAIN CHARACTERISTICS OF BONY FISHES

- 1) Inhabit all sorts of water—fresh, brackish or salt; warm or cold.
- 2) Body is spindle-shaped and streamlined.
- 3) Fins both median and paired, supported by fin rays of cartilage or bone. Tail fin usually homocercal.
- 4) Skin with many mucous glands, usually with embedded dermal scales of 3 types; ganoid, cycloid or ctenoid. Some without scales. No placoid scales.
- 5) Endoskeleton chiefly of bone. Notochord replaced by distinct vertebrae. Pelvic girdle usually small. The claspers are absent
- 6) Mouth is terminal or subterminal. Jaws usually with teeth. Cloaca is absent and anus is present.
- 7) Respiration by 4 pairs of gills on bony gill arches, covered by a common operculum on either side.
- 8) Air (swim) bladder often present with or without duct connected to pharynx. Lung-like in some (Dipnoi).
- 9) Two-chambered ventral heart (1 auricle + 1 ventricle). Sinus venosus and conus arteriosus are present. Aortic arches 4 pairs. Erythrocytes are oval shaped and nucleated. Temperature is variable (poikilothermous).
- 10) Adult kidneys are mesonephric. Excretion is ureotelic.
- 11) Brain with very small olfactory lobes, small cerebrum and well developed optic lobes and cerebellum. Cranial nerves 10 pairs.
- 12) Well developed lateral line system. Internal ear with 3 semicircular canals.
- 13) Sexes are separate. Paired gonads. Fertilization usually external. Mostly oviparous, rarely ovoviviparous or viviparous. Eggs minute

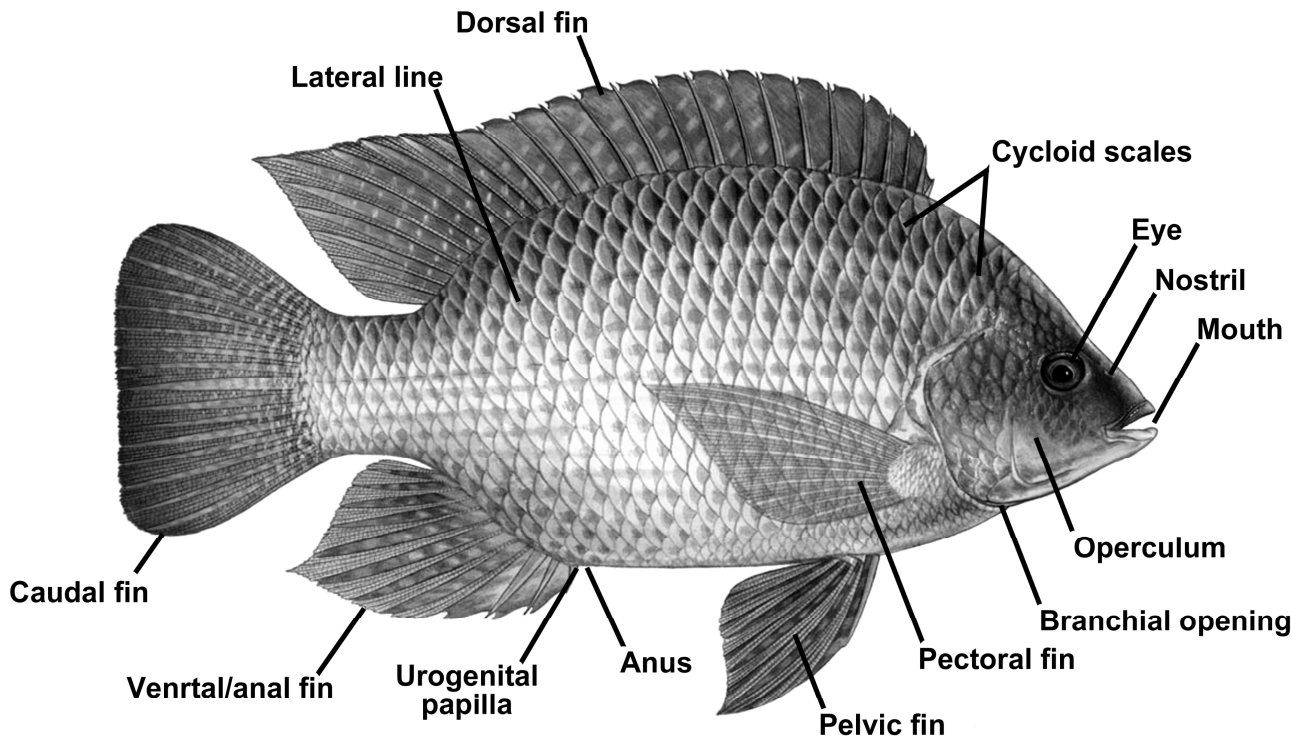
to 12 mm. cleavage is meroblastic. Development is direct and rarely with metamorphosis.

EXTERNAL FEATURES

The body is bilaterally compressed and subdivided into head, trunk, and tail regions, is generally streamlined. On each side of the head it bears a large **eye**, lacking lids. Posterior to it, the preopercular region, containing the bones that help support the jaws, and the opercular region, containing the opercular bones covering the gills. Anteriorly to each eye, there is an external **nostril**.

On the trunk and caudal peduncle, the prominent **lateral line** forms a distinct ridge along the scales. The trunk region is covered with **scales** (**cycloid** scales), other teleosts may have ctenoid scales or completely lacking scales. The concentric growth rings on the embedded portion of the scale can be used to age an individual. There are three median fins, the **dorsal** fin, **anal** fin, and **caudal** fin. The dorsal fin is larger and is supported by ossified fin rays. The anal fin is on the ventral midline, just anterior to the tail, and is supported mainly by soft fin rays. The **homocercal** caudal fin is symmetrical. The paired fins are represented by the **pectoral** and **pelvic** fins.

Unlike the shark, the perch does not have a cloaca. Instead, the digestive tract has a separate opening, an **anus**, the large, circular opening anterior to the anal fin. The **urogenital aperture** is considerably smaller and less evident, and lies immediately posterior to the anus.

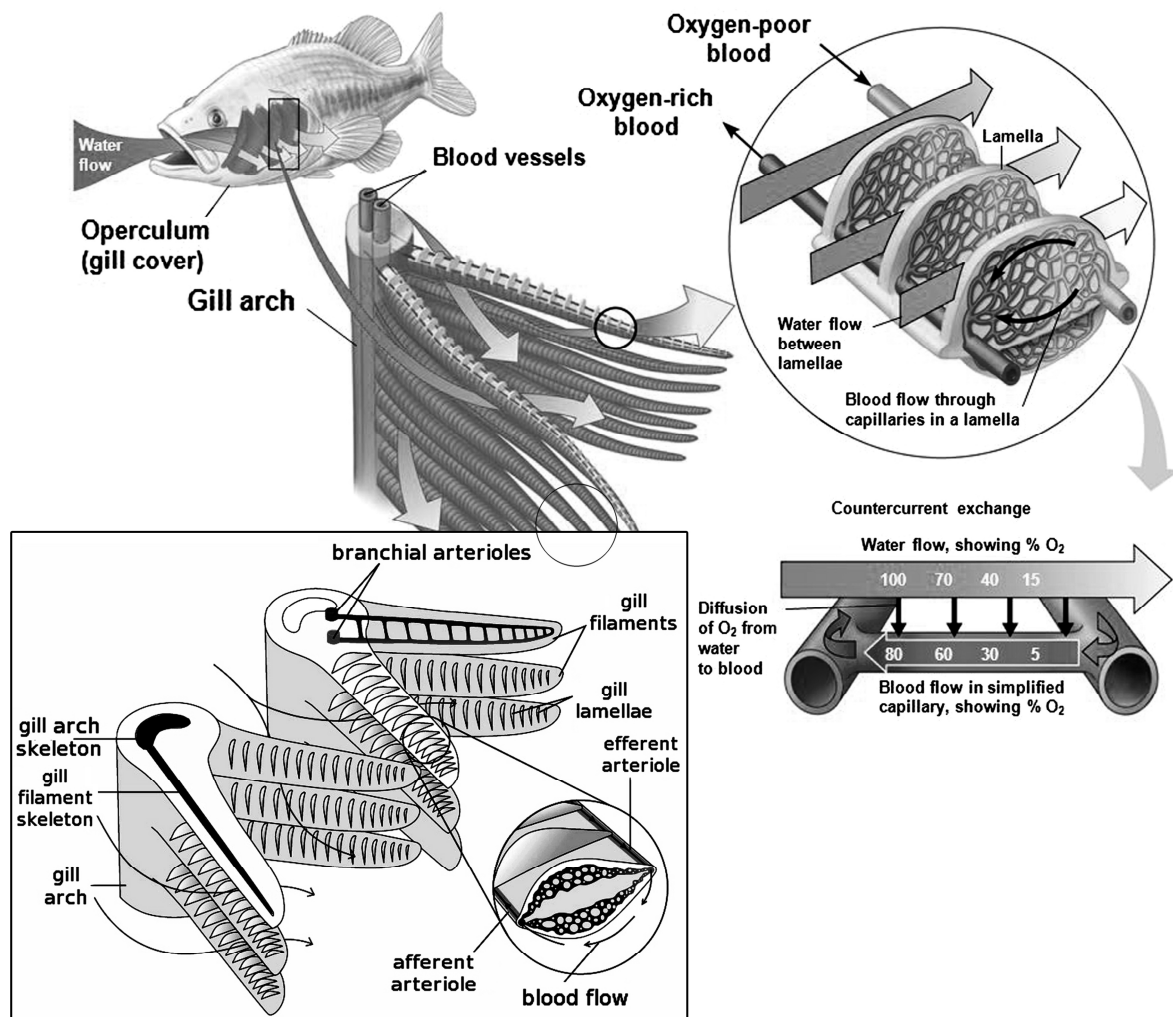


. External features of the *Tilapia nilotica*

RESPIRATORY SYSTEM

Bony fishes depend on O₂ dissolved in water. The respiration is performed by four pairs of **gills** located in gill chambers. There are 4 pairs of **filiform** gills supported by the first 4 pairs of gill arches. Each gill chamber is covered externally by a skin flap, the **operculum**, supported by bony plates. There are four **holobranchs** only attached to four branchial arches. The inner or pharyngeal border of each gill arch has teeth-like processes, the **gill rakers**, which do not permit food particles to enter the gill chamber. Every gill filaments bears several minute

transverse plates or **lamellae** covered with thin epithelium and containing capillaries between the afferent and efferent branchial vessels.



Diagrammatic cross section of gills of a bony fish showing its structure, water flow and the mechanism of gas exchange.

MECHANISM OF RESPIRATION

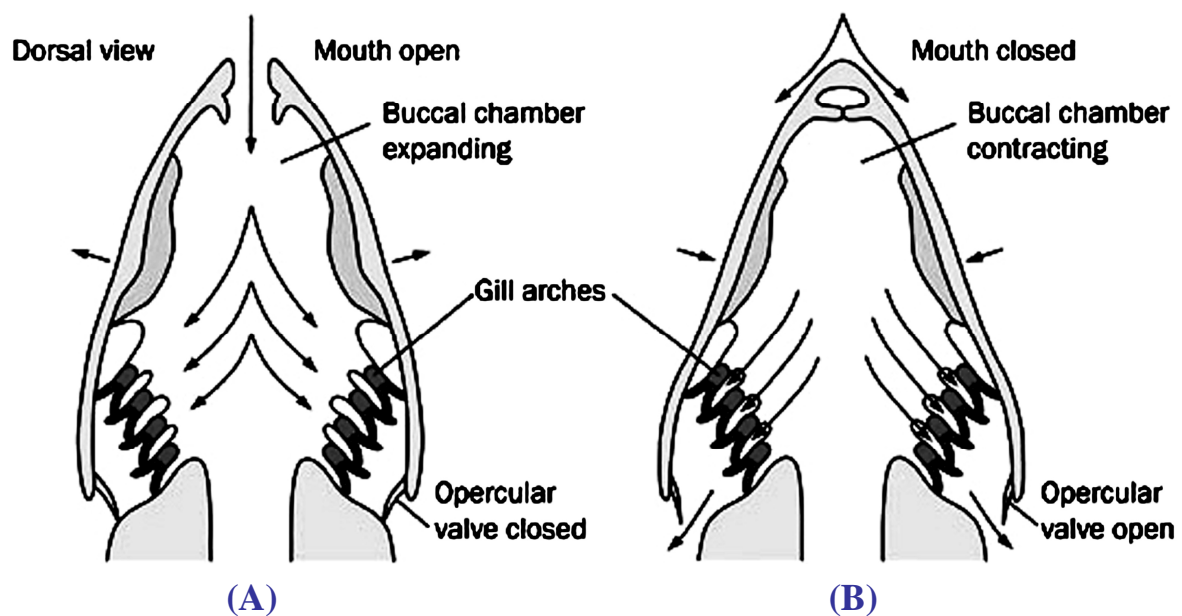
Breathing movements occur in two steps, the gill chambers working as suction pumps:

INSPIRATION

During inspiration, opercula press against the body keeping the two external branchial apertures tightly closed. The gill arches bulge laterally enlarging the internal capacity of bucco-pharyngeal cavity which acts like a suction pump. As result, the oral valves open and water flow in through opened mouth to fill the bucco-pharyngeal cavity.

ExPIRATION

Now the oral valves close shutting the mouth, the gill arches contract and the opercula lift, opening the external branchial aperture. Consequently, water under pressure is forced to pass over the gill filaments and out through the external branchial aperture.



the changes during the processes of inspiration (A) and exhalation (B) of a bony fish.

SWIMMING BLADDER

In higher teleosts, the swimming/air bladder tends to be divided into two chambers, demarcated by a constriction with a sphincter. Essentially air bladder is tough sac-like structure with an overlying capillary network. Just beneath the capillary protocercal there is a layer of connective tissue called **tunica externa**. Below this layer lies the **tunica interna**, made up of chiefly smooth muscle fibers and epithelial **gas glands**. The wall of anterior chamber has a remarkable red body or **red gland** so called because of its color. It contains a compact mass of interlacing fine capillaries called **rete mirabile**. The red gland receives blood from *coeliaco-mesenteric artery* and empties into the *hepatic portal vein*. Gases in the bladder come from blood secreted by the red gland. The posterior chamber is thin-walled and forms the **oval gland** which permits reabsorption of gases by the blood. Secretion and resorption are under the control of *autonomic nervous system*.

FUNCTION OF SWIMMING BLADDER

RESPIRATION

In lower or intermediate fishes, such as **ganoids** and **lung fishes**, the air bladder serves as a **lung**. These fishes come to water surface regularly to gulp air. In physostomous (with duct) teleosts, which also gulp air, the bladder serves as an accessory respiratory organ. Even in physoclistous (ductless) teleosts, the bladder is said to store oxygen to be utilized during deficiency.

HYDROSTASIS

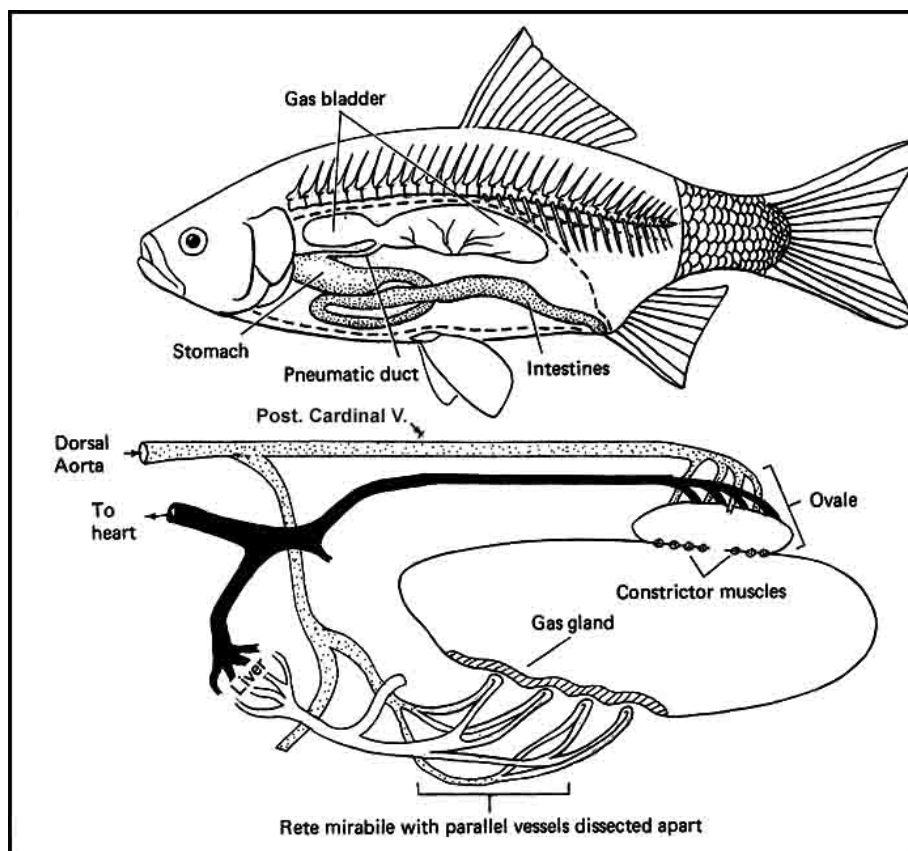
Air bladder act as **hydrostatic organ** and helps to keep the weight of the body equal to the volume of water displaced by fish. Secretion of more gases means lower specific gravity so that fish rises in water. Resorption of gases means increased specific gravity and the fish sinks.

SOUND PRODUCTION

Some fishes are able to produce sounds with the gases inside air bladder by the use of special muscles attached to the air bladder. *Malapterurus Sp.* can produce **grunting**, **hissing** or **drumming** sound. The circulation of air inside the bladder causes the vibration of incomplete septa, which in turn, produces sound.

Audition

In *Cypriniformes*, a series of small bones, the **weberian ossicles**, connects the air bladder and peri-lymph cavity containing internal ear. Low-frequency vibrations of the contained gas, induced by noises in water, are transmitted by the ossicles to the membranous **labyrinth**. Thus, these fish can hear.



Comparison of Chondrichthyes and Osteichthyes:

Characteristic	Chondrichthyes (Cartilagenous fishes)	Osteichthyes (Bony fishes)
1-Habitat	Mostly marine	Both marine and freshwater
2-Shape	Usually dorso-ventrally flattened	Usually bilaterally flattened
3- Caudal fins	Heterocercal	Homocercal or diphycercal
4-Pelvic fins	Usually posterior. In male form claspers for transferring sperms into genital tract of female.	Usually anterior, sometimes posterior. Claspers absent. Whenever present not formed by pelvic fins.
5-Mouth opening	Ventral on head. Large and crescendo	Terminal on head. Variable in shape and size.
6-Gill openings	Usually 5 pairs of naked gill slits. No operculum.	5 pairs of gill-slits covered by a lateral flap of skin called operculum, so that a single gill opening on either side
7-Spiracles	Usually 1 st gill slit becomes spiracles which open just behind eyes.	Spiracles are lacking.
8-Cloaca	Between two pelvic fins lies midventrally common cloacal opening for alimentary, urinary and genital products.	Cloaca absent. Anus and urinary and genital apertures open separately.
9-Exoskeleton	Separate dermal placoid scales	Overlapping dermal cosmoid, ganoid, cycloid or ctenoid scales
10-Endoskeleton	Wholly cartilaginous	Mostly bony
11-law suspension	Hyostylic	Hyostylic and autostylic
12-Stomach	Typically J-shaped	Shape variable. Absent in some
13-Intestine	Short and with an internal fold or scroll valve in lumen	Long and without scroll valve
14-Rectal gland	Present	Absent
15-Liver	Generally has 2 lobes	Generally has 3 lobes
16-Type of gills	Lamellibranch with long interbranchial septum	Filiform with reduced interbranchial septum
17-Air (swim) bladder	Absent	Usually present
18-Conus arteriosus	Present	Absent
19-Afferent branchial vessels	5 pairs from ventral aorta to gills	Only 4 pairs
20-Efferent branchial vessels	9 pairs	4 pairs
21-Brain	Primitive with larger olfactory lobes & cerebrum and smaller optic lobes and cerebellum.	Advanced with smaller olfactory lobes and cerebrum and larger optic lobes and cerebellum.
22-Restiform bodies	Present in brain	Absent
23-Ductus endolymphaticus	Open on top of head	Do not open to exterior
24-Retina	Lacks cones	Cones present
25-Accommodation of eye	Lens moved forward by protractor lentis muscle.	Lens moved back by retractor lentis muscle
26-Ampullae of Lorenzini	Present	Absent
27-Male genital duct	Connected to anterior genital part of kidney	Not connected with kidney
28-Oviducts	Not connected to ovaries	Connected to ovaries
29-Urinary and genital apertures	United and urinogenital apertures lead into common cloaca.	Separate and open independently to exterior
30-Fertilization	Internal	External in water
31-Eggs	Few, large with much yolk	Numerous, small with less yolk
32-Development	Internal in ovoviviparous types. Externally inside egg cases in oviparous types.	Usually external without an egg case